SAFETY BY DESIGN

Safe design of healthcare facilities

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The physical environment has a significant impact on health and safety; however, hospitals have not been designed with the explicit goal of enhancing patient safety through facility design. In April 2002, St Joseph's Community Hospital of West Bend, a member of SynergyHealth, brought together leaders in healthcare and systems engineering to develop a set of safety-driven facility design recommendations and principles that would guide the design of a new hospital facility focused on patient safety. By introducing safety-driven innovations into the facility design process, environmental designers and healthcare leaders will be able to make significant contributions to patient safety.

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> ''We shape our buildings and afterwards our buildings shape us.'' Winston Churchill, 1941.[1]

The design of a facility, including its technology and equipment, creates a physical environment in which caregivers provide services. Can this physical environment be designed to improve patient safety?

Humans err. The reason for the sentinel 1999 Institute of Medicine (IOM) report *To err is human: building a safer health system* was just that: to stress the fact that physicians, caregivers—in fact the entire human race—all err.[2] James Reason and Lucian Leape's model of error contends there are conditions, which cause interruptions to human neurological systems, and these lead to human error.[3 4] If these conditions causing human error are minimized or eliminated in a context such as hospitals, the result should be less human error, leading to fewer adverse events and preventable medical deaths, improved patient outcomes, and improved safety.

What are these conditions of human error and does a hospital facility, with its equipment and technology, affect them?

The architect Bruce Mau, in his book *Massive change*, has this to say about the importance of design: ''For most of us, design is invisible. Until it fails. … When systems fail, we become temporarily conscious of the extraordinary force and power of design. Every accident provides a brief moment of awareness of real life, what is actually happening, and our dependence on the underlying systems of design.''[5]

Similarly, in his book *The challenge of interior design*, Kleeman states, ''There are those who assert that essentially the design of an interior space and its location not only can communicate with those who enter it but also controls their behavior.''[6] In *The psychology of everyday things*, Norman reports that humans do not always behave clumsily and do not always err, but are much more likely to when things they use are badly conceived and designed.[7] And finally, Moray sums it up well by saying that ''people of good intention, skilled and experienced, may none the less be forced to commit errors by the way in which the design of their environment calls forth their behavior.''[8]

In sum, experts from various fields agree that the physical environment does have a significant impact on safety and human performance. The research done by Reason and Leape testifies to the value of practices based on principles designed to compensate for human cognitive failings. When applied to the healthcare field, these include, for example, standardization, simplification, and use of protocols and checklists.[4]

Facilities designed to meet fire safety codes, for example, impact the health and safety of employees, patients, and families.[9] In *The role of the physical environment in the hospital for the 21st century: a once-in-a-lifetime opportunity*,[10] Ulrich and Zimring reviewed more than 600 articles and found rigorous studies that link the physical environment to patient and staff outcomes in four areas:

1. reduced staff stress and fatigue; increased effectiveness in delivering care
2. improved patient safety
3. reduced stress and improved outcomes
4. improvement in overall healthcare quality.

Human factors analysis, ''the study of the interrelationships between humans, the tools they use, and the environment in which they live and work'', is basic to any study of a hospital's design and its effect on the performance of the people who interface with the facility and its fixed and moveable equipment and technology.[11] As a result, the design of a facility with its fixed and moveable components can have a significant impact on human performance.

St Joseph's Community Hospital of West Bend, a member of SynergyHealth, is an independent, non-profit, 80-bed acute care hospital located in West Bend, Wisconsin, near Milwaukee. Its affiliate, West Bend Clinic, also a member of SynergyHealth, is a multispecialty group of more than 45 physicians serving patients in three locations.

In the unique position of building a new hospital, St Joseph's recognized the opportunity to increase patient safety and promote a patient-safe culture by improving the traditional hospital facility design process. With billions of dollars spent annually on healthcare construction, St Joseph's identified the need to develop a set of safety-driven design principles that could be used by all healthcare organizations—whether they are building a new facility, remodeling, or expanding an existing facility.

Internal discussion at St Joseph's focused on how design of a new facility could affect patient safety. St Joseph's contacted leaders in patient safety, quality improvement, and human factors to seek their advice. The belief was that there was an opportunity to learn collectively about how a facility could be designed to improve patient safety.

In April 2002, leaders in systems engineering, healthcare administration, health services research, human behavior research, hospital quality improvement and accreditation, hospital architecture, medical education, pharmacy, nursing, and medicine participated in a conference entitled Charting the Course for Patient Safety—A Learning Lab, sponsored in part by a grant from the University of Minnesota, Carlson School Program in Health Administration. These leaders represented organisations such as:

- American Hospital Association (AHA)
- American Medical Association (AMA)
- American Pharmaceutical Association (APhA)
- American Society for Quality (ASQ)
- Institute for Healthcare Improvement (IHI)
- Institute for Safe Medication Practice (ISMP)
- Joint Commission on Accreditation of Healthcare Organization (JCAHO)
- Medical Group Management Association (MGMA)
- National Patient Safety Foundation (NPSF)
- Patient Safety Institute (PSI)
- University of Minnesota (U of MN)
- University of Wisconsin-Milwaukee (UW-Milw)
- Veterans Administration, Midwest Patient Safety Center of Inquiry (VA)
- Veterans Healthcare Administration (VHA)
- Wisconsin Hospital Association (WHA)

Derived from the learning lab was the collective belief that safe hospitals could be designed using a process that supports the anticipation, identification, and avoidance of failure; by designing against the latent conditions and active failures which compromise physical and organizational defenses; and, by creating an organizational culture of safety.

Participants in the learning lab were instructed to consider human error, why it occurs, and which factors undermine human performance. A great deal of information has been published on dealing with human error from a systems approach.[8 12 13] In a systems approach, error reduction is achieved by strategically building defenses, barriers, and safeguards into the facility, equipment, and processes that make up the system. In order to achieve this, an understanding of the types of errors present is necessary. Reason classifies errors found in complex systems such as healthcare as either active failures or latent conditions.[8 14]

In medicine, active failures are errors made by those who provide direct care to the patient such as physicians, nurses, and technicians. Latent conditions are those conditions that are present in the system, the facility, equipment, and processes that contribute to or combine with active failures to produce error. Latent conditions typically arise from decisions made by management, architects, and equipment designers. Examples of latent conditions present in a healthcare facility include lack of standardization of equipment and procedures, poor visibility, high noise levels, and excessive movement of patients. Unlike active failures that are difficult to predict, latent conditions can be identified and remedied with safety barriers before they can contribute to an adverse effect. Safety barriers act to prevent a healthcare provider from committing an active failure or by mitigating the effect of an active failure.[15]

Participants, through a multi-voting process, created recommendations for facility design, safety culture, and process. The recommendations and principles have been categorized as either process recommendations (box 1), safety design principles (box 2), or safety culture (box 3), and are aimed at minimizing latent conditions, reducing active failures, and creating a facility design process and culture focused on patient safety. The safety design principles specifically address latent conditions and active failures, while the process recommendations identify critical components of the facility design process. The learning lab participants modified the traditional facility process driven by the commitment to patient safety (box 4).

Box 1 Safety design process recommendations

1. Matrix development (post learning lab)
2. FMEA at each stage of design
3. Patients/families involved in design process
4. Equipment planning from day 1
5. Mock-ups from day 1
6. Design for vulnerable patients
7. Articulation of a set of principles for measurement
8. Establishment of a checklist for current/future design

Box 2 Safety design principles

1. Noise reduction
2. Scalability, adaptability, flexibility
3. Visibility of patients to staff
4. Patients involved with their care
5. Standardization
6. Automate where possible
7. Minimizing fatigue
8. Immediate accessibility of information, close to the point of service
9. Minimizing patient transfers/handoffs
10. Design around precarious events

   – Operative/post-op complications/infections
   – Inpatient suicides
   – Correct tube—correct connector—correct hole placement events
   – Medication error related events
   – Wrong site surgery events
   – Oxygen cylinder hazards
   – Deaths of patients in restraints
   – Transfusion related events
   – Patient falls
   – MRI hazards

Box 3 Safety culture recommendations

1. Shared values and beliefs about safety within the organization
2. Always anticipating precarious events
3. Informed employees and medical staff
4. Culture of reporting
5. Learning culture
6. Just culture
7. Blame-free environment recognising human fallibility
8. Physician teamwork
9. Culture of continuous improvement
10. Empowering families to participate in care of patients
11. Informed and active patients

Box 4 Steps in the traditional facility design process

- Role and program
- Functional space programming
- Adjacencies (block diagrams)
- Schematic design
- Design development
- Construction documents
- Construction

TOOLS AND METHODOLOGY TO FOCUS ON PATIENT SAFETY

Matrix development

The matrix development process was actually developed after the learning lab, and it was used to brainstorm ideas and design features to meet the learning lab's safety design principles. It was also used to prioritize the potential design features, technology, and equipment to maximize safety while maintaining the budgets and capital available. St Joseph's modeled the matrix using the quality functional deployment technique. The quality functional deployment matrix (house of quality) matches the voice of the customers to technical requirements.[16] In our applications the ''voice of the customers'' were the National Learning Lab requirements for active failures reduction and latent conditions management. Other ''voices'' were meeting the design principles adopted by the board, and capital cost requirements.

Failure modes and effects analysis at each stage of design

Few issues about patient safety are raised in the traditional healthcare facility design process. St Joseph's has redefined this process to include the application of failure modes and effects analysis (FMEA) at each stage.

Faced with no experience in the application of FMEA to healthcare facility design, we looked to other industries for expertise and guidance. The American Society of Quality (ASQ) and an expert in the auto industry provided support and training to design and architect/construction team representatives.

The design teams determined the traditional FMEA approach was too complex for healthcare facility design and developed a modified approach. They began by simplifying the FMEA spreadsheet to use a revised severity/occurrence scoring system. Instead of traditional numerical scoring, teams were asked to score failure occurrence and effects as low, medium, or high. This modified process identified potential failures of design and their relative priority, which was an important element in making design decisions.

Patients/families involved in the design process

Involving patients and family members is an important component in the facility design process. At St Joseph's, focus groups were held and surveys were conducted at several points in the design process. Focus group suggestions on the patient room design led to an important relocation of the patient chair to allow an unrestricted path to the bathroom.

Equipment planning beginning on day 1

Most hospitals begin equipment planning late in the design process. Equipment planning on day 1 ensures that the equipment technology and facility interfaces are maximized to meet the safety objectives. At St Joseph's, technology options were developed to determine which systems could be implemented immediately or at the completion of the new facility, and those that could be acquired in the future. Priorities included automated systems where possible to eliminate human error, and decision support and patient information available at the point of care. Initial technology plans included centralized scheduling, a nurse call system, pneumatic tube transport, and automated systems for pharmacy, rapid admissions, and management of materials.

Mock-up planning beginning on day 1

Many different types of mock-ups exist from two-dimensional to computer generated to physical construction. At St Joseph's, two mock-up rooms were physically constructed, one on the Medical/Surgical floor and the other in the New Life Center. The rooms went through multiple revisions including such important features as door sizes, locations of patient chairs, and lighting sources and locations.

Mock-up rooms can serve two functions in addition to designing a safer environment: simulation on systems, and future education and orientations. With a mock-up, simulations can be conducted on redesigned or current processes such as routine functions, medication delivery to a patient room, or emergency codes and other complex circumstances.

Design for vulnerable patients

There is a time during each patient's treatment when they are at their most vulnerable point. This can occur when they first come in for treatment and are very sick, or immediately after treatment such as surgery. During these critical times, particular attention must be given to identify and minimize the risks to the patient.

Designing hospital spaces around the common needs of patient groups may require that rooms look and function differently but share similar processes and technology. When making design decisions, the solutions should maximize safety for the most vulnerable patient. Particular attention should be paid to movement of patients, transfers, visibility, and patient room design.

Vulnerable patients should typically have limited movement and exposure to the public. This is a consideration when making decisions regarding the adjacencies of departments, location of patient elevators, and ''patient only'' corridors. In addition, standardized procedures should be used during movement of patients and transfers to ensure that complete and accurate patient information accompanies the patient at all times.

Patient rooms should be designed with maximum visibility. As described earlier, this can be achieved with cameras, windows into rooms from charting alcoves (this will allow visibility without disturbing the patient), and designing rooms in a mirrored image layout where a nurse can view four patients from one location in the hallway. Rooms and bathrooms can be designed larger than a traditional patient room for ease in movement between bed and bathroom. A larger room can also include a comfortable space for family members, which will encourage family involvement and provide additional patient monitoring.

Additional considerations to minimize risk to vulnerable patients include standardization of equipment, and the use of common monitoring systems and intravenous pumps.

Articulate a set of principles for measurement

In order to maintain focus on patient safety, it is important to have a set of safety-driven design principles to guide the design process, and to articulate these principles to all participants involved in the design. In a large building or remodeling project there are often many participants from various backgrounds including architects, contractors, hospital administration and staff, community members, and industry consultants. Many participants may not understand the concepts of latent conditions or active failures, nor appreciate the opportunity to minimize them through facility design. By having a clearly articulated set of safety-driven design principles, all participants will share a common focus and commitment to the design process.

Establish a checklist for current/future design

Developing a checklist of the safety-driven design principles is an important tool in maintaining focus on patient safety during the design process. At St Joseph's, design team members were responsible for completing a checklist of the safety design principles, indicating how they addressed each principle in their proposed design.

UNDERSTANDING AND MINIMIZING LATENT CONDITIONS AND ACTIVE FAILURES

Noise reduction

A report by the World Health Organization indicates that noise interferes with communication, creates distractions, effects cognitive performance and concentration, causes annoyance, and contributes to stress and fatigue. Mental activities involving a demand on working memory are particularly sensitive to noise and can result in degradation of performance. In a study by Murthy *et al*, anaesthesia residents exhibited reduced mental efficiency and poorer short term memory under the noisy conditions of an operating room averaging 77 dB.[17]

In addition to safety considerations, noise affects the quality of the healing environment for patients. It may elevate blood pressure, increase pain, alter quality of sleep, and reduce overall perceived patient satisfaction. Studies in paediatric intensive care units have shown that noise routinely disrupts sleep that is necessary for patient comfort or recovery.[18]

The nature of sound and its reverberation rate (how long the sound remains) has a direct effect on the noise level. When the reverberation rate is long there is greater opportunity for sounds to blend together, increasing the noise level. With speech communication, a longer reverberation time combined with background noise makes speech perception increasingly difficult.

St Joseph's has many design features to minimize noise. Examples are: no overhead paging, quiet floor coverings (carpet, rubber), ''quiet'' HVAC (heating, ventilating, and air conditioning) systems, private rooms, private standardized rooms with insulation between the rooms, more absorbent ceiling tile, and ''quiet'' equipment and technology.

Scalability, adaptability, flexibility

Scalability is the ability to expand or remodel easily so that latent errors are not designed into the building expansion. Adaptability is the ability to adapt space for different or evolving services so that latent errors are not built in.

Many design and construction concepts can be applied to achieve a scalable or adaptable healthcare facility—everything from open spaces with modular systems, to infrastructure requirements, and expansion zones that support scalable and adaptable buildings. Specific examples that St Joseph's has incorporated into the facility design include: ceiling heights (floor to floor) to allow for expansion or changes, and wiring or wireless technology that will allow future technology to be easily implemented. Key services located on outside walls allow for expansion sizing of patient rooms and provide greater adaptability.

Visibility of patients to staff

Visibility of patients to staff is an important issue regarding patient safety and quality in the healthcare setting. There is little debate that healthcare organizations trail their peers in service innovation. In the 19th century, it was said that form follows function. In the 21st century, it is becoming clear that form shapes function. A well chosen form helps providers deliver services more efficiently and cheaply.[19] A pod structure allowing close proximity to their patients allows nurses to deliver improved quality, while enabling them to be more efficient and effective.

Unit designs must allow caregivers to be visual in proximity to the patients under their care as well as accommodate the more traditional orientations of broader based patient responsibility. This can be accomplished by designing multiple mini-nursing stations throughout the unit, offering alcoves for charting and dictation and allowing for wall desks, whether in corridors or patient rooms. In addition, visibility can be enhanced through patient rooms designed in a mirrored image layout, with adjoining charting alcoves, cameras in rooms, windows in the charting alcoves, and convenient locations of supplies.

Patients involved with care

According to the IOM report, *Crossing the quality chasm*, many patients have expressed frustration with their inability to participate in decision making, to obtain information they need, to be heard, and to participate in systems of care that are responsive to their needs.[20]

Gerteis *et al* have identified several dimensions of patient-centered care: (1) respect for patients' values, preferences, and expressed needs; (2) coordination and integration of care; (3) information, communication, and education; (4) physical comfort; (5) emotional support—relieving fear and anxiety; and (6) involvement of family and friends.[20] Many of these dimensions have facility implications, including those of equipment and technology.

In addition, during a hospital stay, keeping patients and family members informed can also potentially reduce errors or potential errors. For example, patients or their family members should receive a daily schedule of prescribed medication and treatments. They should be encouraged to verify this information with the caregivers administering the medication or treatment. In addition, providing a comfortable space for family members to stay in the patient's room also facilitates their involvement with care.

Standardization

Care standardization could substantially impact the basic consequences of organizational factors, enough to reduce medical errors and improve quality. Errors, like human failures in any other sphere, are not just isolated causes; they are themselves the consequences of upstream organizational factors or latent conditions.[3]

Facility impact on behavior is a documented and researched relationship in several areas, including commercial aviation and information and communications technology; however very little is known about facility impact on standardization and how it affects the medical error rates and quality of care.

Much of the work in human factors focuses on improving the human/system interface by designing better systems and processes. This includes standardization of patient rooms, treatment areas, equipment, and procedures. The standardization of the facility and room design, from the location of the outlets, to the bed controls, to which cupboard the latex gloves are stored, the charting process, even switches on light fixtures—down to the most minute detail—all have an impact on behavior.

In *The psychology of everyday things*, Norman talks about design novelty, stating, ''Users don't want each new design to use a different method for a task. Users need standardization.''[7] Specific examples to consider in facility standardization are:

- Truly standardized patient rooms
- Ambulatory care rooms
- Gases and equipment
- ''Migrating'' toward standardized IVs, beds, and monitors
- Medication systems and other care processes.

Automate where possible

In *Crossing the quality chasm: a new health system for the 21st century*,[20] the IOM identifies information technology (IT) solutions as a necessary component to improving patient safety. The IOM challenges the government and the healthcare industry to make a commitment to develop an information infrastructure to support healthcare delivery that would lead to the elimination of most handwritten data by the end of the decade.

When designing a new healthcare facility, technology planning should begin early in the design process. If possible, ongoing assessment of the type and frequency of errors within the existing institution will assist in determining specific technological needs and setting priorities. To facilitate the decision process, it is beneficial to create a list of those IT systems needed and/or desired and to characterize those systems according to their relationship to one another, impact on patient safety, financial investment, implementation time, and their impact on facility design and operation. The financial investment should reflect the total cost of ownership, including costs for purchase, implementation, maintenance, and staff support.

Minimize fatigue

Research has identified fatigue as a possible contributing factor of human error.[15] Although research has not proven the effects of fatigue on patient safety, studies have shown that fatigue has a negative impact on alertness, mood, and psychomotor and cognitive performance; all of which can have an impact on patient safety.[21–23] Studies of surgical residents suggest that manual dexterity and fine motor skills may be compromised as a result of sleep deprivation.[24]

Shift work and, in certain circumstances, long hours and increased workloads are inevitable in patient care. As a result, minimizing fatigue is a complex issue in hospitals that requires a comprehensive approach. In facility design, this could mean minimizing the distances staff must travel between patient rooms, nurses' stations, and treatment areas. This could affect not only the number of patient rooms per floor but also vertical and horizontal adjacencies of departments. The use of technology can increase the efficiency of workload and reduce the reliance on short term memory and thought processes. One example is the computerized tube transport system that can either eliminate or significantly reduce the need for staff to hand deliver laboratory specimens, blood products, or medical supplies, thus increasing efficiency of workloads.[25] Noise reduction, as previously recommended, is another method of minimizing fatigue in both hospital staff and patients. Additional recommended strategies from the literature include limiting work hours and on-call periods, using forward rotation of shift work (morning to evening to night shifts), developing workstation environments that minimize distractions from patient care, alertness strategies such as napping and caffeine, and education of physicians and staff about the negative effects of sleep deprivation and fatigue and the importance of good sleep habits.[22–24]

Immediate accessibility of information at the point of service

In order to provide patients with the most accurate diagnosis and treatment possible, physicians need to have complete, ''real-time'' information about the patient, suspected illness, and treatment options. Research has shown that lack of knowledge and information can lead to errors.[14] Two significant causes of adverse drug events (ADEs) and potential ADEs are lack of drug knowledge and inadequate availability of patient information.[26]

Technologies have been developed that can assist physicians and other caregivers with complex cognitive tasks such diagnosis and treatment by providing ''real-time'' medical information.[27] Examples of these technologies include the internet, computer-based patient records, and clinical decision support systems.

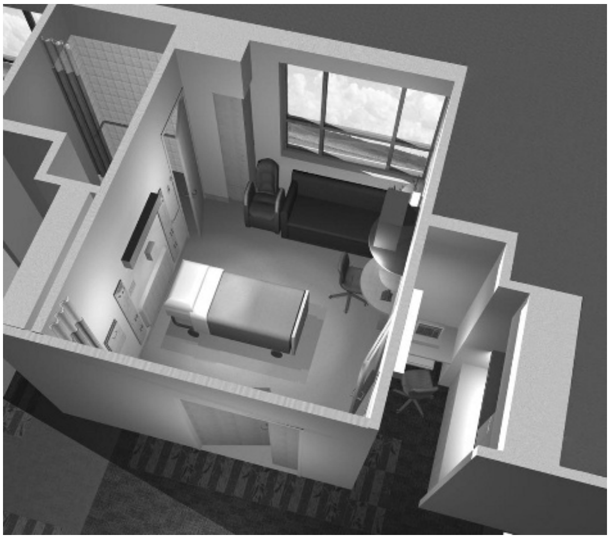
In addition to technological solutions, other methods for improving the visibility of patient information can be used. Charting alcoves directly adjacent to patient rooms can provide easy access to patient charts without disrupting the patient. In surgery, operating rooms can be equipped with large boards or monitors displaying patient information and scheduled procedures that can be verified against physician instructions and the patient's chart and medical records.

Minimizing patient transfers/handoffs

Participants at the National Learning Lab discussed this issue from a variety of perspectives. Transferring patients puts both patient and staff in a vulnerable position in which patients or staff could be harmed, and causes disruption for ill patients. Usually a transfer from a patient room involves multiple transfers. A patient is transferred to surgery or to radiology, transferred to a table in those locations, and usually returns to be transferred to the patient bed again.

Often, these transfers involve handoffs: nurse to transporter to radiology tech to transporter to nurse, creating the potential for error or harm. Many other handoffs occur in a facility involving many caregivers, such as physician to nurse to nurse to radiology tech to lab techs, and so on, in high risk circumstances. These conditions are ripe for error.

Minimizing patient transfers/handoffs, or minimizing the risk of harm when transferring patients, have many facility design implications. It is safer to design services to come to the patient, not the reverse. This design needs to be adaptable so services in the future can come to the patient. Potential errors due to transfers and handoffs can be minimized by having lifts in every care area in the hospital, barcoding for patient identification, and electronic medical records, so that



Patient room, St Joseph's Hospital, 2005.

complete and accurate information is available for caregivers at the point of service where handoffs occur.

Designing around precarious events

The precarious events (active failures) should be based on a healthcare institution's own database of sentinel events, adverse events, medical errors and near misses; and then on national databases such as those from the Joint Commission on Accreditation of Hospital Organizations (JCAHO) and the Veterans Administration National Patient Safety Center.

According to JCAHO, a *sentinel event* is an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof.[28] Such events are called "sentinel" because they signal the need for immediate investigation and response. According to the IOM, an *adverse event* is defined as an injury caused by medical management rather than by the underlying disease or condition of the patient. A *medical error* is defined as the failure of a planned action to be completed as intended (error of execution) or the use of a wrong plan to achieve an aim (error of planning).[2] A *near miss* is defined as an error that does not result in harm to the patient.

The facility design process at St Joseph's focuses on preventing the occurrence of the following 10 precarious events and their root causes identified from a review of the databases of JCAHO and the Veterans Administration National Center for Patient Safety.[28 29] Space should be sized so that as many services as possible can be provided in the patient room.

- *Operative/post-op complications/infections.* Locate sinks in every patient care area so they are visible to patients; standardize visibility and location of sanitizer dispensers.
- *Inpatient suicides.* Implement patient room features to reduce suicide attempts.
- *Correct tube–correct connector–correct hole/oxygen cylinder hazards.* Standardize connectors; standardize head walls in every room in the hospital; segregate tanks in storage room in central plan; standardize medical air throughout the facility.
- *Wrong-site surgery.* Standardize operating room (OR) suites; install proper lighting; install cable for access to digital images and photographs of surgery site along with *x* rays.
- *Events relating to medication errors/transfusion related events.* Make certain that proper wiring/cabling is included in all "non-traditional" areas where medication may be dispensed or delivered; technology applications such as pharmacy decision support, barcoding, computerized physician order entry (CPOE), or electronic medical records (EMR) should be integrated with "appliances" such as IV pumps.
- *Deaths of patients in restraints.* Consider visibility of patients in design phase; provide comfortable space for family members to stay with patient.
- *Patient falls.* Develop bed exit technology to notify caregivers when patients are attempting to get out of bed.
- *MRI hazards.* Create a three-zone MRI suite; use a duplicated checklist; use hand-held metal detectors at point of entry; colour code any MRI compatible equipment; consider computer chip technology.

Using the recommended tools and methodology focusing on patient safety, St Joseph's patient room demonstrates minimising latent conditions and active failures through application of the safety design principles and designing around precarious events. The design of the patient room, coupled with technology and equipment recommendations, will institute changes in nursing and physician processes and workflow to increase patient safety. The "truly" standardized patient room reflects the following safety design features aimed at creating a safe, high quality, patient-centered environment:

- Charting alcove with window to increase patient visibility for nurses, physicians, and staff.
- Oversized window allowing more natural light into the patient room and creating a better healing environment.
- Wiring for cameras in every room.
- Standardization in room size and mirrored image layout; standardized equipment and supplies.
- Improved technology including EMR and CPOE to reduce medication errors; an advanced nurse call system (including wireless phones); and a bed exit system to reduce patient falls.
- Ceiling heights and room size to allow for easy expansion.
- Noise reduction using low vibration steel, special noise absorbing ceiling tiles, and no overhead paging.
- Bedside computers allowing patient access to records and involvement with care as well as providing caregivers convenient access to patient information.
- Sitting area and guest foldout bed to encourage family support and involvement with care.
- In-room sink allowing physicians and staff to wash hands (within patient view) to reduce the spread of infections.
- Close proximity between bed and bathroom with railing support to reduce the potential for patient falls.
- Special "break away" bathroom fixtures to reduce suicide attempts.
- Bathroom is at the head of the patient's bed, allowing the patient to get to and from the bathroom without impediments, holding onto a rail all the way if necessary.
- The flooring of the patient room is rubber, second to carpet in sound reduction qualities.

CONCLUSION

The 2002 National Learning Lab has had a powerful effect on St Joseph's and is influencing other hospital facility development, both nationally and internationally. St Joseph's fully implemented the recommendations of the National Learning Lab, modifying the traditional design process, designing around latent conditions and active failures, and enhancing

Key messages

- Latent conditions and active failures in a healthcare setting can be minimized through strategic improvements to the design of the facility.
- St Joseph's Community Hospital of West Bend has developed a set of safety-driven design principles and recommendations that can be used by all healthcare organizations, whether they are building a new facility, remodeling, or expanding.
- Using a clearly defined set of safety design principles and process recommendations will ensure that all participants in the design process share a common goal and focus on patient safety.

or creating safety culture through facility design with its technology and equipment.

St Joseph's has also received an AHRQ Grant to assist in the implementation of our major technology platform, Epic, and to assess the impact of the new institution on safety and quality. Studies have been completed on the original St Joseph's and those same studies will be conducted in 2007 to assess the differences the new facility with its technology and equipment has on latent conditions, active failures, length of stay, patient satisfaction, safety culture, and cost per discharge.

The new hospital opened in August of 2005. The planning of the move under the direction of the VP of Patient Care Services, Mike Murphy, evolved over a year's time, using the tools we used in designing the hospital; FMEA, time outs, standard processes, etc. The outcome was a smooth, incident-free move. Staff simulated caring for patients for about two months before opening, and oriented themselves to the new facility. A SWAT team was formed for the first few weeks to assist staff in addressing concerns after the opening. This group of employees representing technology services, materials services, clinic services, etc, were available 24 hours a day to support the needs of transitioning employees.

The facility opened on time and under budget. In fact, St Joseph's was able to add significant programs and enhance its safety features as a result of being under budget. The timing of the project allowed us to receive competitive bids with the high level of standardization. For example, cost concerns were expressed about fully standardized patient rooms compared to back-to-back patient rooms. The contractors actually felt fully standardized was at least the same, if not less, cost than back-to-back patient rooms.

Opening a new hospital is a dramatic transaction for an organization. New technologies coupled with persuasive process modifications create significant change behavior. As much as we tested the technologies and processes, we still discovered issues around both. The simulations and orientations were very helpful but additional orientation and technology testing would have been useful.

We have had an opportunity to conduct tours for many organizations around the opening of the new hospital and after the opening. The effects of the design around latent conditions (box 2) is apparent. Quiet environment, improved air flow, standardization, etc, all exhibit the commitment St Joseph's had to safety by design. Staff from all areas have expressed their pride for influencing the design so they can provide safe care. It was truly a transforming experience to have been able to participate in the design of St Joseph's.

Architects, mechanical engineers, mechanical architects, general contractors, nurses, administration, board members, physicians all expressed their personal transformation at a recent National Learning Lab celebration. We changed our building and afterwards, our building changed us.

John Reiling is former President/CEO of SynergyHealth, St Joseph's Hospital, current Principal Investigator for the AHRQ Grant and current President/CEO of Safe by Design.

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